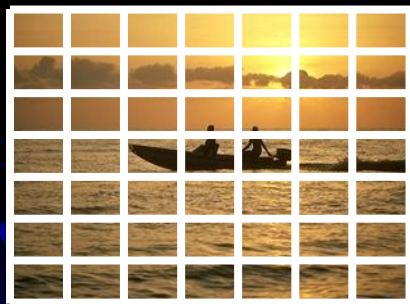


- Roll call
- Announcements:
 - Reinstall Matlab if you are having problems: Lab 1 has directions.
 - Angel has drop box for Lab 1
 - Bonus points to first person to find errors in course materials!
 - Next class: lots more Matlab how-to (bring laptop)
- Last class we discussed:
 - Today: Color and color features
 - Answer questions 1-2 about ICME sunset paper now
 - Questions?

Pixels to Predicates

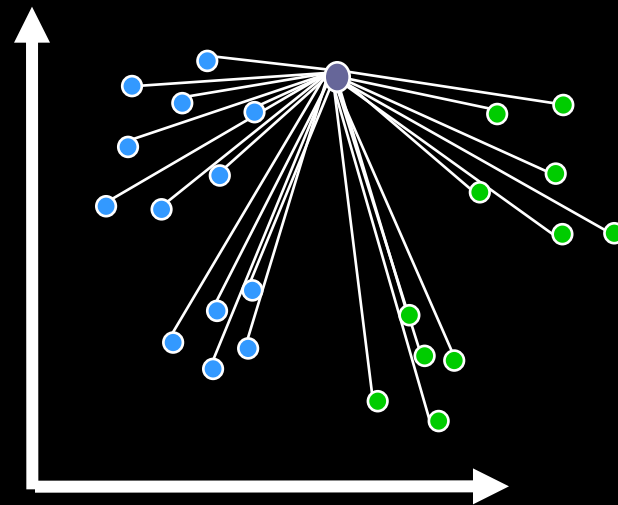
1. Extract features from images



$$x = \begin{pmatrix} 0.4561 \\ 0.1928 \\ \dots \\ 0.2756 \end{pmatrix}$$

Color
Texture
Shape
Edges
Motion

2. Use machine learning to cluster and classify

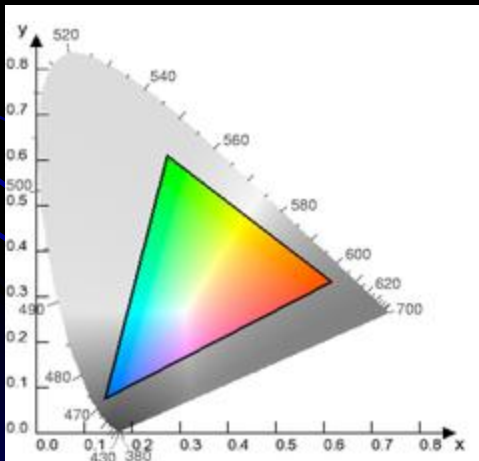


Principal components
Neural networks
Support vector machines
Gaussian models

Basics of Color Images



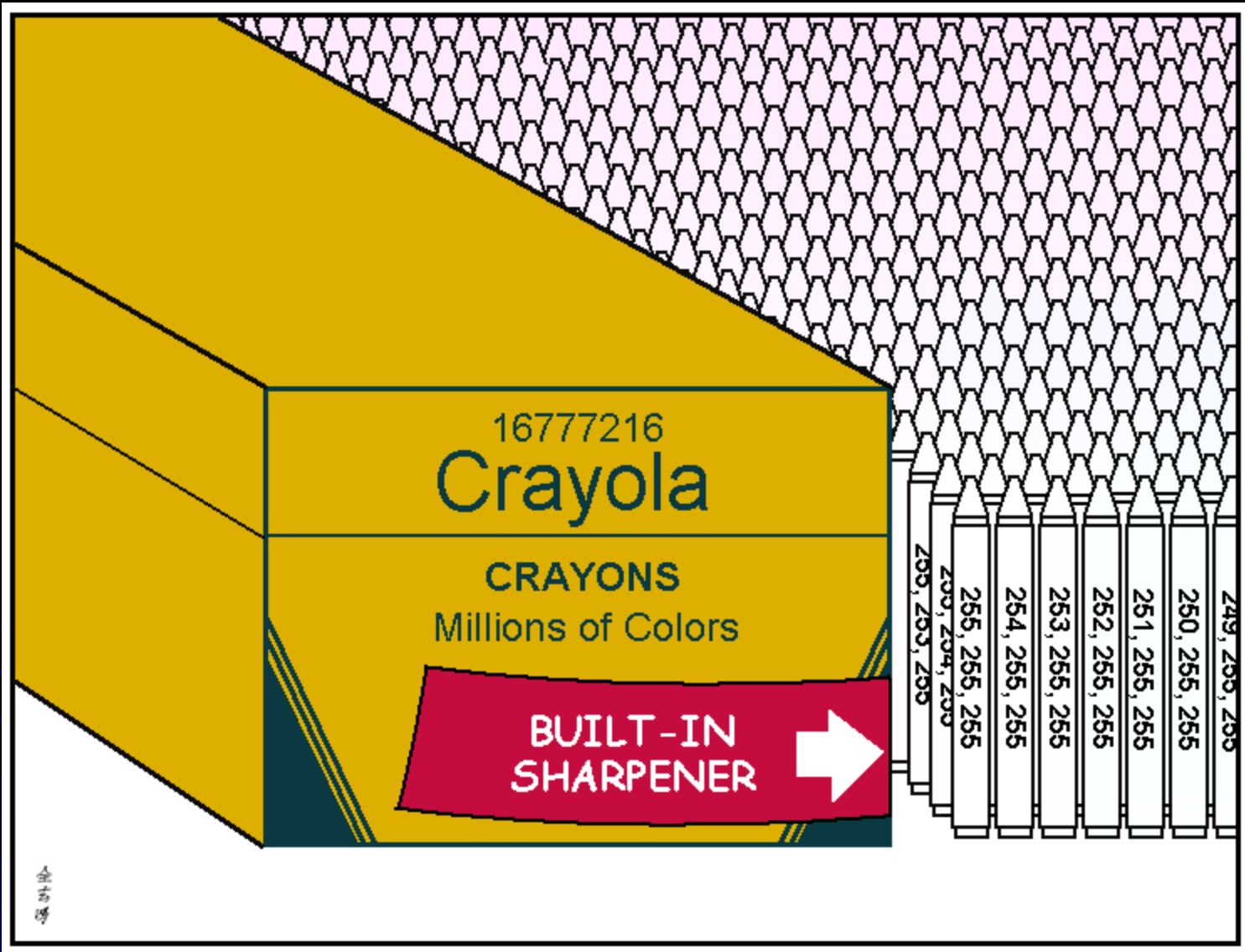
- A color image is made of red, green, and blue *bands*.
 - Additive color
 - Colors formed by adding primaries to black
 - Comments from graphics?
 - RGB mimics retinal cones in eye.
 - RGB used in sensors and displays
 - Why “16M colors”?
 - Why 32 bit?



Source: Wikipedia

Basics of Color Images

- Each band is a 2D matrix
- Each R, G, or B value typically stored in a byte.
 - Range of values?
- The 4th byte is typically left empty
 - Allows for quicker indexing, because of alignment
 - Reserved for transparency (in graphics)
- How much storage is required for a 4 megapixel color image (uncompressed)?



金吉博

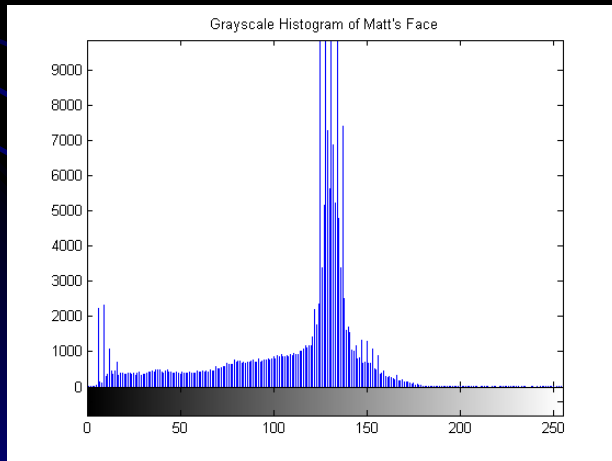
We can extract different types of color features (statistics) from images

- 1. Color histograms
- 2. Color moments
- 3. Color coherence vectors

Related considerations:

- Some color spaces “work better”
- Spatial components can help

Color histograms



- Gives distribution of colors
- Sample to left is for intensities only
- Pros
 - Quantizes data, but still keeps lots of info
- Cons
 - How to compare two images?
 - Spatial info gone
 - Histogram intersection (Swain and Ballard)

Color moments



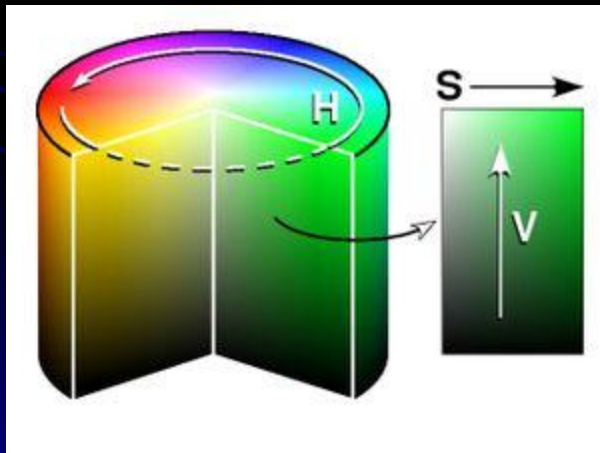
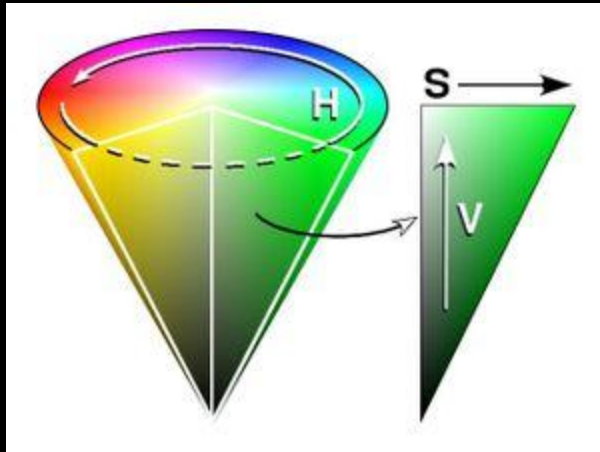
$m_1 = 116.3$
 $m_2 = 1152.9$
 $m_3 = -70078$
 $m_4 = 7.4$ million

$m_1 = 132.4$
 $m_2 = 2008.2$
 $m_3 = 4226$
 $m_4 = 12.6$ million

- Central moments are *statistics*
 - 1st order = mean
 - 2nd order = variance
 - 3rd order = skew
 - 4th order = kurtosis
 - Some have used even higher order moments, but less intuitive
- For color images, take moments of each band

$$m_d = \frac{1}{n} \sum_{i=1}^n (x_i - \mu)^d$$

HSV color space



Source: Wikipedia

- Hue-saturation-value (HSV) cone
 - also called HSI (intensity)
 - Intuitive
 - H: more than “what color”: it’s wavelength; position on the spectrum!
 - S: how vibrant?
 - V: how light or dark
- “Distance” between colors
 - Must handle wraparound of hue angle correctly ($0 = 2\pi$)
- Matlab has method to convert from rgb to hsv, can find formula [online](#).

Other color spaces

- LST (Ohta)

- L = luminance: $L = (R + G + B) / \sqrt{3}$
- S and T are *chroma* bands.
 - S: red vs. blue: $S = (R - B) / \sqrt{2}$
 - T: green vs. magenta: $T = (R - 2G + B) / \sqrt{6}$

- These 3 are the *principal components* of the RGB space (PCA and eigenvectors later in course)

- Slightly less intuitive than HSV
- No problem with wraparound

- Y. I. Ohta, T. Kanade, and T. Sakai, Color information for region segmentation, Computer Graphics and Image Processing, Vol. 13, pp. 222-241, 1980.

- Others

- YIQ (TV signals), QUV, Lab, LUV
- http://www.scarse.org/docs/color_faq.html#graybw

Spatial component of color



- Break image into parts and describe each one
 - Can describe each part with moments or histograms
- Regular grid
 - Pros?
 - Cons?
- Image regions
 - Pros?
 - Cons?

Additional reading

- Color gamuts
 - <http://en.wikipedia.org/wiki/Gamut>
- Color coherence vectors
 - Extension of color histograms within local neighborhoods
 - Used in:
 - A. Vailaya, H-J Zhang, and A. Jain. On image classification: City images vs. landscapes. Pattern Recognition 31:1921-1936, Dec 1998.
 - Defined in:
 - G Pass, R Zabih, and J Miller. Comparing images using color coherence vectors. 4th ACM Conf. Multimedia, pp 65-73, Boston, 1996.